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"Spillovers and Taxes: What Drives Strategic Competition in Environmental Policies?"

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Abstract: It has been widely shown in the literature that states act strategically when forming environmental policies. However, this strategic interaction could be the result of two different effects. In the hypothesis of tax competition, states strategically set environmental standards in order to attract a fixed amount of mobile capital. In a spillover model, states set environmental policies strategically in response to pollution that spills over from other states. The previous literature has been unable to separate the two effects. Using weighting matrices specifically tailored to each form of competition, I am able to separate the effects, showing that tax competition explains 38% of interaction in environmental policy while spillover competition explains 62%.

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Spillovers and Taxes: What Drives Strategic Competition in Environmental Policies?

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Abstract

It has been widely shown in the literature that states act strategically when forming environmental policies. However, this strategic interaction could be the result of two different effects. In the hypothesis of tax competition, states strategically set environmental standards in order to attract a fixed amount of mobile capital. In a spillover model, states set environmental policies strategically in response to pollution that spills over from other states. The previous literature has been unable to separate the two effects. Using weighting matrices specifically tailored to each form of competition, I am able to separate the effects, showing that tax competition explains 38% of interaction in environmental policy while spillover competition explains 62%.

Keywords: Strategic Interaction, Environmental Policy, Tax Competition, Spillover Competition

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The fact that emissions of harmful pollutants often cross state lines creates a situation where states may engage in strategic interaction. This possibility is greatest for air pollution since air pollutants can often travel long distances before causing damage. If California releases an extra ton of sulfur dioxide, it is possible that other states will react in a number of different ways. First of all, other states may emit more, feeling that if California emits more, it would be politically acceptable if they do as well. Alternatively, downwind states may decrease their emissions to reduce damages, compensating for California's emissions. Thirdly, if California's emissions have increased due to some loosening of environmental regulation, other states may also lower their stringency in an effort to compete for mobile capital. All of these are examples of strategic interaction in the specific area of air pollution. This paper explains which of these situations is the main driver of strategic interaction in environmental stringency. I find that, in general, tax competition explains a larger amount of competition than spillover competition. Furthermore, I show that higher marginal damages from pollution limit competitive behavior among states.

Many empirical papers have found evidence that governments compete strategically in the formation of fiscal policies. There are two basic models that generate these results: the spillover model and the resource-flow model (Brueckner, 2003). While these models generate the same results, they are motivated by different assumptions. In the spillover model, the assumption is that governments strategically respond to other governments' policies because their policies spill over from one jurisdiction to another. For example, one city might spend less on park services if the adjacent city has already invested in parks. The park benefits spill over because they are available to both cities. Alternatively, governments might consider other governments' policies because of competition to have the "best" policies. Similarly, they might use other governments' policies as a benchmark on which they base their own policies. This type of competition is called spillover competition, in which yardstick competition is a specific case with political motivations.

In contrast, the resource-flow model assumes that the strategic behavior occurs due to competition over a fixed supply of resources. A good example of this behavior is state competition in attracting industries to locate in-state (Tasto, 2007). One way that states accomplish this is by reducing taxes on firms, thus giving rise to the term, "tax competition."

In the cases I have mentioned above, the source of the strategic interaction is fairly clear. However, in many cases, both spillover competition and tax competition might be driving the results. The stringency of environmental regulation is one of these cases. Elements of both spillover models and resource-flow models are present in the case of strategic interaction in environmental stringency as described in the introductory paragraph.

Fredrikkson and Millimet (2002) find evidence that states react strategically to other states' environmental stringency, but they are unable to disentangle the effects of spillover and tax competition. I propose a method for distinguishing between the two types of competition. All strategic interaction models use weighting matrices to model the pattern of interaction among states. I exploit this aspect of the models by specifying two different weighting matrices: one that corresponds to spillovers and one that represents tax competition. Previous papers (e.g. Fredriksson and Millimet, 2002) state that the ideal weighting matrix for spillover competition would account for state-to-state pollution flows. I construct this weighting matrix using the source-receptor matrix from an integrated assessment model of pollution dispersion and valuation. Since tax competition focuses on competition between states for mobile capital, it is presumed that this competition will occur between states with similar industrial structure. Thus, I use a weighting matrix based on Crone's (1999) classification of states into regions defined over industrial composition. I then estimate the response models with the two weighting matrices and with linear combinations of the two matrices to determine the relative contribution of each type of competition.

Section 2 reviews the literature on these models and previous attempts to disentangle the two forms of competition. Section 3 presents the econometric model used to test the hypothesis. Section 4 discusses the methodology of the two tests and the data used in the analysis. Section 5 presents the results and Section 6 concludes.

Literature Review

The seminal paper in the empirical literature on strategic interactions in policy-making is Case, Hines, and Rosen (1993). They test whether states' budgets are influenced by their "neighbors," which is not necessarily defined by contiguity (which states are directly adjacent), but may also be determined by varying degrees of similarity. The authors set up a theoretical model of strategic policy-making, which supports their assertion that states respond to the policies of other states.

Case, Hines, and Rosen specify three options for the weighting matrix used to determine which other states are a state's "neighbors": matrices based on contiguity, similar income, and similar racial composition. They estimate the model with each weighting matrix, and note that the highest log-likelihood reflects the best weighting matrix. They find that the log-likelihood is maximized when using the weighting matrix based on racial composition. In addition, they perform tests using linear combinations of the matrices and find that the racial composition weighting matrix is dominant. All of the weighting matrices show evidence of strategic interaction. The authors, in an attempt to deflect possible criticism that there is some inherent trick to the weighting matrix process that generates positive results, construct an absurd weighting matrix and run the model. No strategic interaction is found. They also break down state spending by categories, but omit the category on environmental spending.

Other examples of spillover-type models include Murdoch, Rahmatian, and Thayer (1993), who examine the case of spillovers in city-level recreation expenditures (if one city invests in particularly attractive parks, nearby cities may attempt to free-ride). Kelejian and Robinson (1993) test a similar situation with spillovers in county-level police expenditures. Environmental spillover models also fall into this category (Murdoch, Sandler, and Sargent, 1997; Fredriksson and Millimet, 2002). Besley and Case (1995) present a model directly based on yardstick competition, noting that constituents may look at the taxes and expenditures of nearby jurisdictions to determine the efficacy of their own government when it comes time for reelection. Bivand and Szymanski (1997; 2000) estimate reaction functions for local garbage collection costs in Britain.

Resource-flow models generate reaction functions based on the assumption that many jurisdictions are competing for a fixed amount of mobile capital. In order to attract capital, the jurisdictions lower their taxes, reduce environmental stringency, or otherwise compete to make their jurisdiction more appealing to the mobile capital. The standard theoretical papers on environmental federalism fit into this category of models (Oates and Schwab, 1988; Wellisch, 1995; Markusen, Morey, and Olewiler, 1995; Levinson, 1997; Kunce and Shogren, 2002, 2005, 2007; Glazer, 1999; Djikstra, 2003; Kunce, 2004; Roelfsema, 2007). Additional resource-flow models (tax competition models) include Brett and Pinkse (2000), who focus on property tax competition; Buettner (2001), who looks at local business taxes in Germany; and Hayashi and Boadway (2001), who look at provincial corporate income taxes in Canada. In addition, country analyses of local tax choices have been conducted for the U.S., Belgium, and the U.K. by Ladd (1992), Heyndels and Vuchelen (1998), and Revelli (2001, 2002) respectively.

Since both the spillover model and the resource-flow model (Brueckner, 2003) generate reaction functions, it is possible that both tax competition and spillover competition are in effect. One weakness of all of these papers is that they are unable to distinguish between the two effects. Some papers have attempted to reinforce the results they obtained by estimating some of the structural equations from the theoretical models that generate the reaction function (Besley and Case, 1995; Brett and Pinkse, 2000). However, these papers only highlight why their reason is the effective reason; they do not explicitly model both sources and attempt to disentangle the effects.

Fredriksson and Millimet (2002) analyze whether environmental stringency, as measured by pollution abatement cost per unit of emissions or the Levinson (2001) index of environmental compliance costs, is strategically determined across states. This situation allows for both tax competition and spillover competition. Several important issues arise when considering environmental policy issues in this context. One such issue is the choice of the weighting matrix. Fredriksson and Millimet use a weighting matrix based on population and income, noting that they are important determinants of state emissions of harmful pollutants. However, they note in a footnote that the ideal weighting matrix in this case would be one that assigned weights according to air pollution transfers. For example, a state would weight most highly the states that spill the most pollution into their borders. Their income/population matrix is supposed to proxy for this. However, I have the benefit of having TAF's source/receptor matrices. I can therefore construct a weighting matrix based on actual pollution transmission.

Fredriksson and Millimet (2002) also estimate the model with asymmetric transmission. Low-stringency states may react to the policies of high-stringency states, but not vice-versa. They also use panel data to determine how long the lag is in the strategic interaction. They find that the lag takes place in two to five years.

Empirical Model

Theoretical models of spillover competition and tax competition abound in the literature beginning with Oates and Schwab (1988). Many of these models predict a "race-to-the-bottom," while some predict a "race-to-the-top." However, both classes of models involve strategic interaction, which are captured in strategic response functions. The standard form for these response functions is

$$E_{it} = X_{it}\beta + \phi\sum_{j=1}^{n} w_{ij}E_{jt} + f_i + h_t + u_{it}\,, \tag{1}$$

where E_{it} represents the stringency of environmental policy of state *i* in year *t*, X_{it} is a vector of demographic, political, and/or social variables, f_i is a state-level fixed effect, h_t is a time dummy, and u_{it} is a random error. Other states' policies enter the reaction function as a weighted average, where the weights w_{ij} are determined beforehand and are assumed exogenous. The parameter of interest is ϕ: if $\phi = 0$, then there is no evidence of strategic interaction.

Instrumental variables regression is necessary in this situation because of several sources of potential endogeneity. If states policies appear correlated due to correlated random shocks, OLS estimation is likely to show a positive value for ϕ even if all correlation is due to random error. These correlated errors are an example of spatial error dependence (Anselin, 1988). Secondly, in a simultaneous estimation, the policy variables are endogenous by assumption: if there were no endogeneity, it would imply that there is no strategic interaction. One way to get around this issue is to avoid simultaneous estimation and use models with lagged dependent variables. Additionally, the model may be subject to "Tiebout bias," where households sort endogenously across states (Goldstein and Pauly, 1981). This causes correlation between the jurisdictional attributes and the error term. The problem is corrected by using panel data and estimated jurisdiction level fixed effects. In the IV approach, the weighted averages of the policies are regressed on the weighted values of the other dependent variables (or a subset of these variables) and the fitted values are then used as instruments. Additionally, one may use higher orders of the weighting matrix to construct additional instruments; for example, W^2X or W^3X. Kelejian and Prucha (1998) show that the instrumental variables approach produces unbiased estimates even in the presence of spatial error dependence.

Data and Methodology

In contrast to previous work, this paper uses distinct weighting matrices to capture both tax competition and spillover competition. For the case of tax competition, I use a weighting matrix based on industry composition as defined in Crone (1999). Crone uses cluster analysis to define regions by economic activity in different sectors. This is ideal for specifying tax competition given the hypothesis that states compete to attract industry. Thus, their main competitors should be those states who have similar industrial structure. Crone regions are shown in Figure 1. Since these regions are not based on contiguity or any sort of pollution flows, the reactions among states in a region should be mostly independent of spillover effects.

For the case of spillover competition, I use the source-receptor matrix from the Tracking and Analysis Framework (TAF) model (Bloyd et al., 1996). This matrix is based on actual pollution spillovers from state to state, as defined by the Ambient Source

Trajectory Regional Air Pollution (ASTRAP) model, which is based on eleven years of meteorological data and has been validated by historical emissions data. Each element of the source-receptor matrix indicates the transmission of pollutant (in this case sulfur dioxide) that moves from each state to each other state. Thus, if California emits one extra ton of sulfur dioxide pollution and 0.05 tons of that sulfur dioxide moved into Oregon, then the source-receptor matrix will contain an entry of 0.05 for this movement. Once the source-receptor matrix is extracted from TAF, it needs to be calibrated with pollution levels. I use EPA data on sulfur dioxide emissions from 1976 to calibrate the weighting matrix. This year is used since it is the year before the range of independent variables, thus avoiding endogeneity of the weighting matrix elements. In the final matrix, each state assigns a weight to a neighbor based on the percentage of its damages that are caused by that neighbor.

As in Fredriksson and Millimet (2002), my dependent variables are the Levinson index as discussed in Levinson (2001) and unadjusted pollution abatement and control expenditures (PACE) per dollar of state manufacturing output for the years 1977-1994, excluding 1987.[1] The Levinson index compares actual pollution abatement costs to the predicted abatement costs for each state. The predicted abatement costs are based on national abatement expenditure by industry and the individual state's industrial composition. Thus, a value less than one implies that the state's abatement costs are lower than what would be expected of a state with that industrial composition, while a value greater than one indicates higher than expected costs. The Levinson index can be thought of as PACE per unit of manufacturing scaled to eliminate differences across states due to manufacturing size and composition.

Explanatory variables include state per-capita income, per-capita income squared, per-capita income cubed, population density, and urbanicity. Table 1 displays summary statistics for this data.

I estimate models that incorporate both weighting matrices in linear combinations. The equations are as follows:

$$E_{it} = X_{it}\beta + \phi\sum_{j=1}^{n}(\alpha w_{ij}^{cr} + (1-\alpha)w_{ij}^{TAF})E_{jt} + f_i + h_t + u_{it}, \qquad (2)$$

where E_{it}, X_{it}, f_i, h_t, and u_{it} carry the same interpretation as in equation 1. w_{ij}^{cr} refers to the weight state *i* places on the stringency value of state *j* under the Crone weighting matrix, and w_{ij}^{TAF} refers to the same weight from the TAF weighting matrix. $\alpha \in [0,1]$ and represents the linear combination of the two weights. The model is estimated with the full range of linear combinations to uncover which combination has the most explanatory power.

[1] Levinson Index data is not available for 1987.

Results

Figure 2 shows the R^2 values from the full range of models using Levinson's index as the dependent variable, while Figure 3 shows the same information for models using PACE as the dependent variable. For the case of the Levinson index results, the highest R^2 value (and thus the most explanatory power) occurs at the corner solution of ALPHA=1. This solution implies that the Crone weighting matrix is dominant, and competition in environmental policy is entirely due to tax competition. On the other hand, the PACE results as shown in Figure 2 tell a different story. The PACE results show a maximum R^2 value at ALPHA=0.38, implying that the Crone matrix accounts for 38% and the TAF matrix accounts for the other 62%. This corresponds to the situation where 38% of competition over environmental policy is due to tax competition and 62% is due to spillover competition.

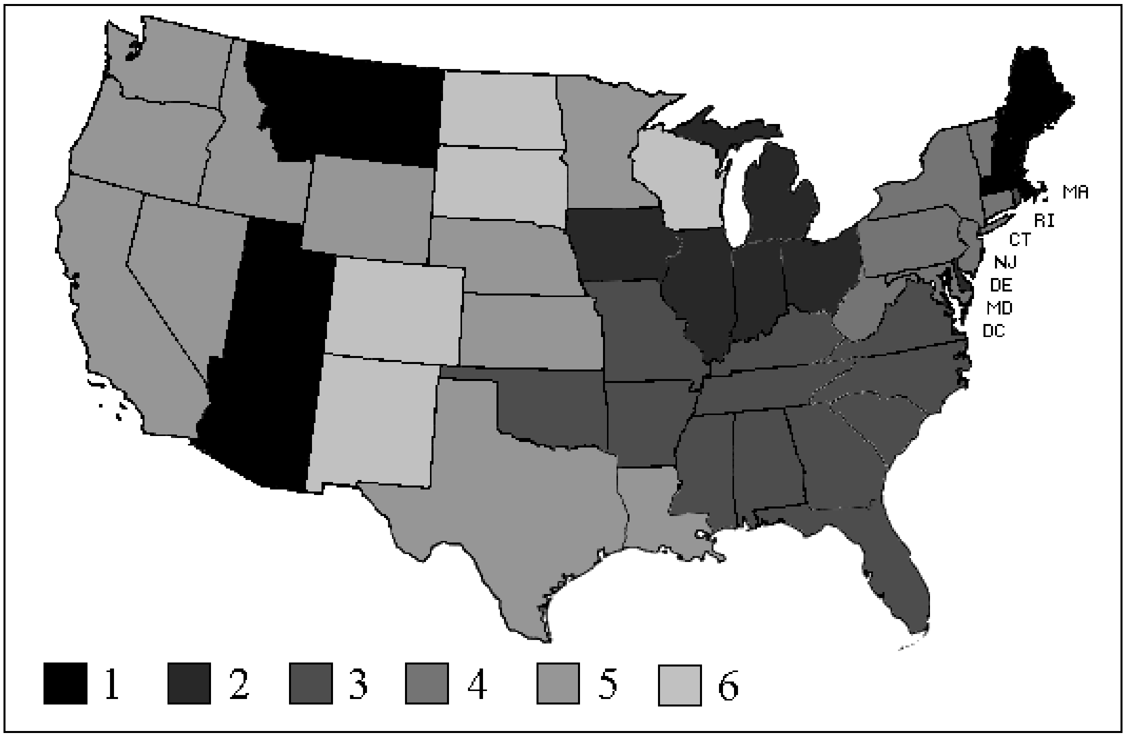
Why do these two dependent variables lead to divergent answers? The Levinson index represents PACE adjusted for the industrial makeup of the state, so the variables are linked. Let us first consider the case where the Levinson index results are assumed correct: 100% of competition in environmental policies is due to tax competition. Were this the case, theoretical research suggests this would lead to either a "race-to-the-top" scenario or a "race-to-the-bottom" scenario (Oates and Schwab, 1988; Wellisch, 1995; Markusen, Morey, and Olewiler, 1995; Levinson, 1997; Kunce and Shogren, 2002, 2005, 2007; Glazer, 1999; Djikstra, 2003; Kunce, 2004; Roelfsema, 2007). Were this the case, empirical research would find evidence of either of these two effects after Reagan's "New Federalism" gave states more power over environmental regulation. However, empirical studies (List and Gerking, 2000; Millimet, 2003; Millimet and List, 2003; Fomby and Lin, 2006) have found no evidence for these effects.

A plausible explanation for the corner solution with the Levinson index may be found in the interactions between the Levinson index and the Crone weighting matrix. The Levinson index represents the PACE values adjusted for industrial composition. The Crone weighting matrix specifies states to be “neighbors” based solely on similarities in industrial competition. Thus, it is possible that, by adjusting for industrial composition twice, the results are biased in some way. Thus, the PACE results are more likely to be correct, given the absence of this double adjustment for industrial composition.

Conclusions

Strategic interaction in environmental stringency can take any of a myriad of forms. The spillover model shows that environmental stringency by be affected by spillover competition, and the resource-flow model implies that tax competition may come into effect. It is also likely that both are present in varying degrees. Using ideally specified weighting matrices, I have shown tax competition accounts for 38% of the strategic interaction in environmental policy while spillover competition accounts for 62% of the interaction. This result is important because both types of competition could have led to the interaction, and it is important to understand policy-makers’ motives in order to best lay out a plan for environmental legislation.

Figure 1—Crone Regions

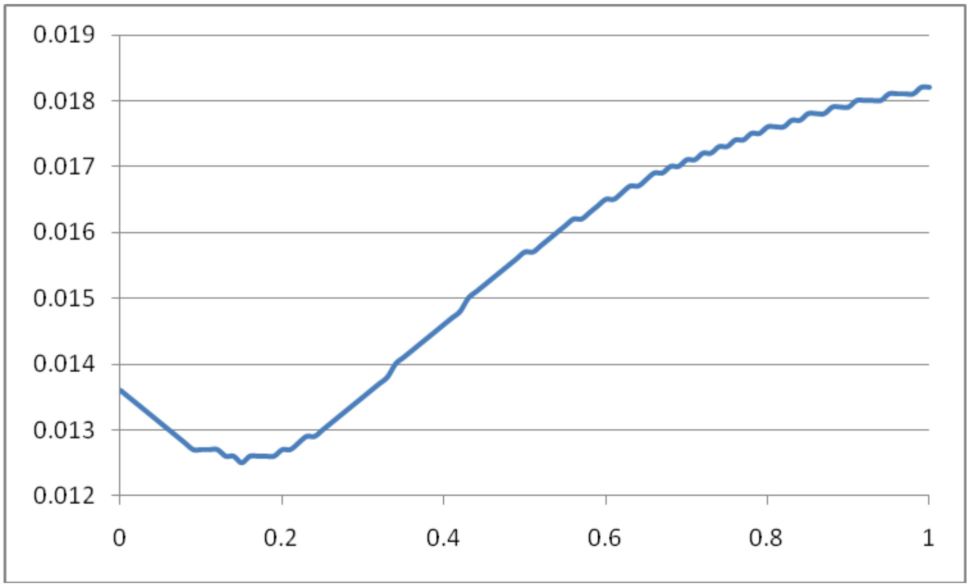


As defined in Crone (1999).

Table 1—Summary Statistics for Strategic Interaction

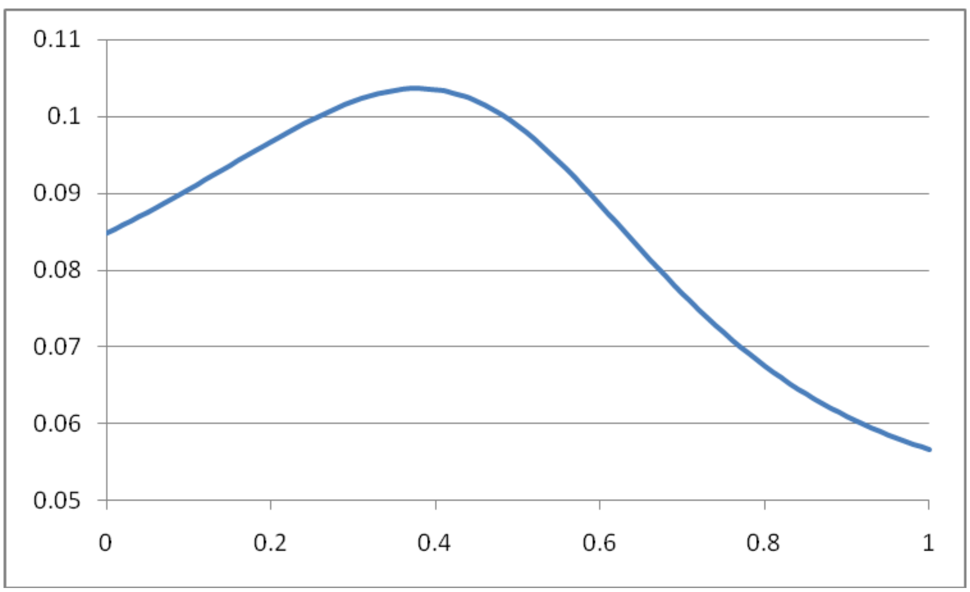
Variable	Definition	Mean	Standard Deviation
Index	Levinson's index of environmental stringency (2001)	1.022371	0.3589778
PACE	Per capita abatement cost of emissions	0.0076315	0.0162409
Pcinc	Per capita income	$14,336.95	2,387.18
Pcsq	Per capita income squared	2.11×10^{8}	7.25×10^{7}
Pccube	Per capita income cubed	3.20×10^{12}	1.72×10^{12}
Popd	Population density (people per square mile)	59.11087	79.84464
Urb	Percent of population that lives in an urban area	0.673099	0.133909
MD	Within-state marginal damages from sulfur dioxide pollution (as derived in Banzhaf and Chupp, 2010)	589.04	792.98

Figure 2—R2 Values for $\alpha \in [0,1]$ using Levinson's Index



The vertical axis measures R2 for the regressions; the horizontal axis corresponds to $\alpha \in [0,1]$, with 0 being the full TAF matrix and 1 being the full Crone matrix.

Figure 3—R2 Values for $\alpha \in [0,1]$ using PACE



The vertical axis measures R2 for the regressions; the horizontal axis corresponds to $\alpha \in [0,1]$, with 0 being the full TAF matrix and 1 being the full Crone matrix.

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